

What is claimed is:

1. A method for making a porous film, comprising the step of:
causing a mobile metal to diffuse to at least one of a cermet film surface and
a ceramic film surface, thereby rendering the porous film, the at least one of the
cermet film and the ceramic film having been formed by co-depositing the metal
and a ceramic on a substrate.
2. The method as defined in claim 1 wherein the co-depositing of the
metal and the ceramic is accomplished by at least one of physical vapor
deposition, chemical vapor deposition, atomic layer deposition, and angle
deposition.
3. The method as defined in claim 1 wherein the metal is at least one of
gold, nickel, platinum, copper, palladium, silver, rhodium, ruthenium, alloys thereof,
and mixtures thereof.
4. The method as defined in claim 1 wherein the ceramic is at least one
of nickel oxides, platinum oxides, Ni-YSZ, Cu-YSZ, Ni-SDC, Ni-GDC, Cu-SDC, Cu-
GDC, silver oxides, samarium strontium cobalt oxide (SSCO, $\text{Sm}_x\text{Sr}_y\text{CoO}_{3-\delta}$),
barium lanthanum cobalt oxide (BLCO, $\text{Ba}_x\text{La}_y\text{CoO}_{3-\delta}$), gadolinium strontium cobalt
oxide (GSCO, $\text{Gd}_x\text{Sr}_y\text{CoO}_{3-\delta}$), lanthanum strontium manganite ($\text{La}_x\text{Sr}_y\text{MnO}_3$),
lanthanum strontium cobalt ferrite ($\text{La}_w\text{Sr}_x\text{Co}_y\text{Fe}_z\text{O}_3$), and mixtures thereof.
5. The method as defined in claim 1 wherein the substrate is at least
one of single crystal silicon, polycrystalline silicon, silica on silicon, thermal oxide
on silicon, alumina, sapphire, ceramic, cubic fluorites, doped cubic fluorites, proton-
exchange ceramics, yttria-stabilized zirconia (YSZ), samarium doped-ceria (SDC,
 $\text{Ce}_x\text{Sm}_y\text{O}_{2-\delta}$), gadolinium doped-ceria (GDC, $\text{Ce}_x\text{Gd}_y\text{O}_{2-\delta}$), $\text{La}_a\text{Sr}_b\text{Ga}_c\text{Mg}_d\text{O}_{3-\delta}$, and
mixtures thereof.

6. The method as defined in claim 1 wherein the causing step is accomplished by subjecting the at least one of the cermet film and the ceramic film to at least one of annealing and sintering.

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7. The method as defined in claim 6 wherein the at least one of annealing and sintering occurs at a temperature between about 750°C and about 1000°C.

10 8. The method as defined in claim 6 wherein the metal is gold and the ceramic is samarium strontium cobalt oxide, and wherein the causing step is accomplished by annealing.

15 9. The method as defined in claim 8 wherein annealing takes place at a temperature ranging between about 750°C and about 850°C.

10. The method as defined in claim 9 wherein the gold agglomerates on the cermet film surface.

20 11. The method as defined in claim 6 wherein the metal is rendered mobile by subjecting the at least one of the cermet film and the ceramic film to reduction.

25 12. The method as defined in claim 11 wherein the metal is nickel and the ceramic is samarium doped cerium, and wherein the causing step is accomplished by annealing.

13. The method as defined in claim 12 wherein nickel is rendered mobile by reduction.

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14. The method as defined in claim 12 wherein the nickel is co-deposited in the presence of 5% oxygen.

5 15. The method as defined in claim 14 wherein an amount of nickel agglomerates on the ceramic film surface, and wherein an amount of nickel oxide remains in the ceramic film, and wherein the method further comprises the step of subjecting the ceramic film having nickel oxide therein to reduction in the presence of hydrogen to render a porous cermet film.

10 16. The method as defined in claim 15 wherein the amount of nickel agglomerated on the ceramic film surface is between about 0% and about 50% of the nickel co-deposited on the substrate.

15 17. The method as defined in claim 15 wherein the reduction takes place at a temperature of between about 400°C and 800°C.

18. The method as defined in claim 11 wherein the metal is platinum and the ceramic is samarium doped cerium, and wherein the causing step is accomplished by sintering.

20 19. The method as defined in claim 18 wherein the platinum is rendered mobile by reduction, and wherein the sintering causes a first amount of platinum which remains in the ceramic film to reduce, thereby rendering a porous cermet film, and wherein the sintering causes a second amount of platinum to agglomerate
25 on the porous cermet film surface.

20. The method as defined in claim 19 wherein oxidation takes place in the presence of 5% oxygen.

21. A method for making a porous film, comprising the steps of:
co-depositing a metal and a ceramic on a substrate, thereby forming at least one of a cermet film and a ceramic film; and

5 subjecting the at least one of the cermet film and the ceramic film to conditions such that the metal reduces, wherein at least a portion of the metal diffuses to a surface of the at least one of the cermet film and the ceramic film, thereby forming at least one of a porous ceramic film and a porous cermet film.

10 22. The method as defined in claim 21 wherein the metal is at least one of gold, nickel, platinum, copper, palladium, silver, rhodium, ruthenium, alloys thereof, and mixtures thereof.

15 23. The method as defined in claim 21 wherein the ceramic is at least one of nickel oxides, platinum oxides, Ni-YSZ, Cu-YSZ, Ni-SDC, Ni-GDC, Cu-SDC, Cu-GDC, silver oxides, samarium strontium cobalt oxide (SSCO, $\text{Sm}_x\text{Sr}_y\text{CoO}_{3-\delta}$), barium lanthanum cobalt oxide (BLCO, $\text{Ba}_x\text{La}_y\text{CoO}_{3-\delta}$), gadolinium strontium cobalt oxide (GSCO, $\text{Gd}_x\text{Sr}_y\text{CoO}_{3-\delta}$), lanthanum strontium manganite ($\text{La}_x\text{Sr}_y\text{MnO}_{3-\delta}$), lanthanum strontium cobalt ferrite ($\text{La}_w\text{Sr}_x\text{Co}_y\text{Fe}_z\text{O}_{3-\delta}$), and mixtures thereof.

20 24. The method as defined in claim 21 wherein the co-depositing of the metal and the ceramic is accomplished by at least one of physical vapor deposition, chemical vapor deposition, atomic layer deposition, and angle deposition.

25 25. The method as defined in claim 21 wherein the co-depositing step takes place in the presence of oxygen.

26. The method as defined in claim 21 wherein the metal is platinum.

27. The method as defined in claim 26 wherein the subjecting step is accomplished by sintering, wherein sintering causes a first amount of the platinum which remains in the ceramic film to reduce, thereby rendering a porous cermet film, and wherein the sintering causes a second amount of platinum to agglomerate on the porous cermet film surface.

28. The method as defined in claim 27 wherein sintering takes place at a temperature ranging between about 750°C and about 1000°C.

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29. The method as defined in claim 21 wherein the metal is nickel.

30. The method as defined in claim 29 wherein the subjecting step comprises the steps of:

15 subjecting the ceramic film to annealing, the ceramic film having nickel oxide therein; and

 subjecting the ceramic film having nickel oxide therein to reduction in the presence of hydrogen.

20 31. The method as defined in claim 30 wherein the reduction takes place at a temperature between about 400°C and about 800°C.

32. A method for making a porous film, comprising the steps of:

25 co-depositing a highly mobile metal and a ceramic on a substrate, thereby forming a cermet film; and

 subjecting the cermet film to annealing, wherein the highly mobile metal diffuses to and agglomerates on the cermet film surface, thereby forming a porous ceramic film.

33. The method as defined in claim 32 wherein the highly mobile metal is gold.

34. A fuel cell, comprising:
5 an electrolyte; and
at least one porous thin film electrode in electrochemical contact with the electrolyte, the at least one porous thin film electrode having been formed by a process comprising the step of:
causing a mobile metal to diffuse to at least one of a cermet film
10 surface and a ceramic film surface, thereby rendering the at least one porous thin film electrode, the at least one of the cermet film and the ceramic film having been formed by co-depositing the metal and a ceramic on a substrate.

35. The fuel cell as defined in claim 34 wherein the electrode comprises
15 at least one of an anode and a cathode.

36. The fuel cell as defined in claim 34 wherein the metal is at least one of gold, nickel, platinum, copper, palladium, silver, rhodium, ruthenium, alloys thereof, and mixtures thereof.
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37. The fuel cell as defined in claim 34 wherein the ceramic is at least one of nickel oxides, platinum oxides, Ni-YSZ, Cu-YSZ, Ni-SDC, Ni-GDC, Cu-SDC, Cu-GDC, silver oxides, samarium strontium cobalt oxide (SSCO, $\text{Sm}_x\text{Sr}_y\text{CoO}_{3-\delta}$), barium lanthanum cobalt oxide (BLCO, $\text{Ba}_x\text{La}_y\text{CoO}_{3-\delta}$), gadolinium strontium cobalt
25 oxide (GSCO, $\text{Gd}_x\text{Sr}_y\text{CoO}_{3-\delta}$), lanthanum strontium manganite ($\text{La}_x\text{Sr}_y\text{MnO}_{3-\delta}$), lanthanum strontium cobalt ferrite ($\text{La}_w\text{Sr}_x\text{Co}_y\text{Fe}_z\text{O}_{3-\delta}$), and mixtures thereof.

38. The fuel cell as defined in claim 34 wherein the substrate is at least one of single crystal silicon, polycrystalline silicon, silica on silicon, thermal oxide

on silicon, alumina, sapphire, ceramic, cubic fluorites, doped cubic fluorites, proton-exchange ceramics, yttria-stabilized zirconia (YSZ), samarium doped-ceria (SDC, $\text{Ce}_x\text{Sm}_y\text{O}_{2-\delta}$), gadolinium doped-ceria (GDC, $\text{Ce}_x\text{Gd}_y\text{O}_{2-\delta}$), $\text{La}_a\text{Sr}_b\text{Ga}_c\text{Mg}_d\text{O}_{3-\delta}$, and mixtures thereof.

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39. An electronic device, comprising:
a load; and
the fuel cell of claim 34 connected to the load.

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40. A method for using a fuel cell, comprising the steps of:
operatively connecting the fuel cell to at least one of an electrical load and
an electrical storage device, the fuel cell comprising:
at least one porous thin film electrode, the electrode having been
formed by a process comprising the step of:

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causing a mobile metal to diffuse to at least one of a cermet
film surface and a ceramic film surface, thereby rendering the porous thin film
electrode, the at least one of the cermet film and the ceramic film having been
formed by co-depositing the metal and a ceramic on a substrate.

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41. The method as defined in claim 40 wherein the diffused mobile metal
agglomerates into metal crystals on the surface of the at least one porous thin film
electrode, wherein the fuel cell further comprises a current collector deposited on
the metal crystals, and wherein the metal crystals substantially enhance current
collection.

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42. A fuel cell, comprising:
at least one porous thin film electrode; and
means for substantially enhancing catalytic efficiency at the at least one
porous thin film electrode.

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43. A catalytic member, comprising:
at least one porous thin film; and
means for substantially enhancing catalytic efficiency at the at least one
porous thin film.

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44. A method for making a porous film, comprising the step of:
forming the porous film by at least one of reducing a metal within at least
one of a cermet film and a ceramic film, and causing the metal to diffuse to at least
one of a surface of the cermet film and a surface of the ceramic film, the at least
one of the cermet film and the ceramic film having been formed by depositing at
least one metal-containing material on a substrate.

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45. The method as defined in claim 44 wherein the at least one metal
containing material is at least one of metals, metal oxides, ceramics, cermets,
binary ceramics.

46. The method as defined in claim 44 wherein at least two of the metal-
containing materials are co-deposited on the substrate.